IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Application of:	Thomas Werner, et al	Examiner:	Daborah Chacko Davis
Serial No.:	10/691,274	Group Art Unit:	1756
Filed:	October 22, 2003	Atty Docket:	2000.105300
		Client Docket:	DE0302
For: Technique For Reducing Resist Poisoning In Forming A Metallization Layer Including A Low-K Dielectric		Confirmation No.:	4933

APPEAL BRIEF

Commissioner for Patents
P.O. Box 1450
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Sir:

Applicants hereby submit this Appeal Brief to the Board of Patent Appeals and Interferences in response to the Final Office Action dated August 20, 2007 and the Notice of Appeal dated October 30, 2007.

The Commissioner is authorized to deduct the fee for filing this Appeal Brief ($510) and any other fees required under 37 C.F.R. §§ 1.16 to 1.21 from the Williams, Morgan & Amerson, P.C. Deposit Account No. 50 0786/2000.105300.

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I. REAL PARTY IN INTEREST

Advanced Micro Devices, Inc., the assignee hereof, is the real party in interest.

II. RELATED APPEALS AND INTERFERENCES

There are no related appeals or interferences of which Applicants, Applicants' legal representative, or the Assignee are aware of that will directly affect or be directly affected by or have a bearing on the decision in this appeal.

III. STATUS OF THE CLAIMS

Claims 1-5, 7-15, and 17-24 are pending in the application. Claims 6 and 16 were canceled. Claims 1-5, 7-15, and 17-24 stand finally rejected and are the subject of this appeal.

IV. STATUS OF AMENDMENTS

A response to the Final Office Action was entered on October 4, 2007. This response included no amendments. All previous amendments have been entered.

V. SUMMARY OF CLAIMED SUBJECT MATTER

In general, a critical level of out-diffusing species from via holes can cause an intolerable degree of resist poisoning when patterning trenches. This poisoning may effectively be avoided by allowing these species to out-gas prior to and throughout the formation of a cap layer of reduced density. Moreover, the reduced density of the cap layer also allows a certain degree of diffusion of resist poisoning species during the formation of a resist mask so that the out-diffusion of the species is no longer restricted to the region within the via hole, thereby efficiently reducing the degree of resist contamination to an uncritical level.

As described starting on page 11, Figure 2a schematically shows a semiconductor structure 200 including a substrate 201, which may have formed thereon a metallization layer 202, for example including a metal region 203 embedded into an insulating material 204. An etch stop/barrier layer 205 is formed over the layer 202. The etch stop layer 205 may be formed of a low-k material, such as silicon carbide, that may contain a certain amount of nitrogen to provide the required barrier characteristics when the underlying metal region 203 comprises copper. A low-k dielectric layer 206 is formed over the etch stop layer 205.

Volatile materials 220, and especially nitrogen and nitrogen compounds, may diffuse into and within the low-k dielectric layer 206. Especially when the etch stop layer 205 comprises a relatively high amount of nitrogen, for example, for improving the barrier and electromigration properties with respect to the underlying metal region 203, nitrogen and nitrogen compounds may readily diffuse into the layer 206. Furthermore, the employment of nitrogen-containing precursor gases in any process steps for forming the etch stop layer 205 and/or the low-k dielectric layer 206 may lead to minute amounts of nitrogen or nitrogen compounds trapped in these layers, which then readily diffuse within the low-k dielectric layer 206.

After completion of the deposition of the low-k dielectric layer 206, the semiconductor structure 200 may be subjected to a heat treatment in a substantially nitrogen-free atmosphere to thereby promote the out-gassing of the volatile materials 220 and especially of nitrogen and nitrogen compounds.

As described starting on page 14, Figure 2b schematically shows the semiconductor structure 200 during a plasma treatment. In the surface portion 223, a silicon dioxide comprising layer 224 is formed, whereby the density thereof is, however, significantly lower than the density of a deposited silicon dioxide layer. Furthermore, due to the amount of silicon dioxide in the layer 224, the permittivity thereof is increased compared to the portion 223. During the ongoing conversion of low-k material into oxide, thereby continuously consuming the surface portion 223, the volatile materials 220 may out-gas through the entire surface of the layer 224 due to the reduced density thereof. It should be noted that even with the full thickness 222, the sacrificial cap layer 224 allows the out-gassing of the volatile materials 220 since the reduced density compared to a conventionally deposited cap layer provides a certain porosity.

Thus, with respect to claim 1, a method, the subject matter comprises:

- forming a low-k dielectric layer (206) over a substrate (201); {p. 11, l. 23 – p. 12, l. 24; Figure 2a}
- heat treating said substrate (201) to promote out-gassing of volatile materials for a predetermined period of time after forming the low-k dielectric layer (206); {p. 13, ll. 7-19; Figure 2a, Figure 2b}
- converting an upper portion of said low-k dielectric layer (206) into a protective dielectric to form a sacrificial cap layer (224) after heat treating said substrate (201); and {p. 14, l. 15 – p. 15, l. 9; Figure 2b, Figure 2c}

- patterning said sacrificial cap layer (224) and said low-k dielectric layer (206). {p. 15, l. 11 – p. 17, l. 7; Figures 2d – 2h}

With respect to claim 11, a method, the subject matter comprises:

- forming a silicon-based low-k dielectric layer (206) over a substrate (201); and {p. 11, l. 23 – p. 12, l. 24; Figure 2a}
- heat treating said substrate dielectric layer (206) to promote out-gassing of volatile materials for a predetermined period of time after forming the low-k dielectric layer (206); {p. 13, ll. 7-19; Figure 2a, Figure 2b}
- forming a silicon dioxide layer (224) as a sacrificial cap layer (224) on said low-k dielectric layer (206) after heat treating said substrate (201), wherein volatile materials continue to out-gas from said low-k dielectric layer (206) prior to and during the formation of said silicon dioxide layer (224). {p. 14, l. 15 – p. 15, l. 9; Figure 2b, Figure 2c}

VI. GROUNDS OF REJECTION TO BE REVIEWED ON APPEAL

A. Whether claims 1-5 and 11-15 are obvious under 35 U.S.C. § 103(a) over U.S. Patent No. 6,348,736 (McGahay) in view of U.S. Patent No. 5,610,105 (Vines).

B. Whether claims 7-10 and 17-22 are obvious under 35 U.S.C. § 103(a) over McGahay in view of Vines and U.S. Patent Publication No. 2002/0090822 (Jiang).

VII. ARGUMENT

A. McGahay and Vines do not obviate claims 1-5 and 11-15.

Claims 1-5 and 11-15 stand rejected under 35 U.S.C. § 103(a) as allegedly being obvious over U.S. Patent No. 6,348,736 (McGahay) in view of U.S. Patent No. 5,610,105 (Vines).

The invention, as set forth in independent claims 1 and 11 includes, among other things, the general features of forming a low-k dielectric layer over a substrate, heat treating the substrate to promote out-gassing of volatile materials for a predetermined period of time after forming the low-k dielectric layer, and forming a sacrificial cap layer over the low-k dielectric layer after heat treating the substrate.

As admitted by the Office Action McGahay fails to teach or suggest heat treating the substrate for a predetermined period of time to promote out-gassing prior to forming the sacrificial cap layer. The Office Action relies on Vines as teaching this feature.

To establish a *prima facie* case of obviousness, three basic criteria must be met. First, there must be some suggestion or motivation, either in the references themselves or in the knowledge generally available to one of ordinary skill in the art, to modify the reference or to combine reference teachings. Second, there must be a reasonable expectation of success. Finally, the prior art reference (or references when combined) must teach or suggest all the claim limitations. The teaching or suggestion to make the claimed combination and the reasonable expectation of success must both be found in the prior art, and not based on applicant's disclosure. *In re Vaeck*, 947 F.2d 488, 20 U.S.P.Q.2d 1438 (Fed. Cir. 1991); M.P.E.P. § 2142. Moreover, all the claim limitations must be taught or suggested by the prior art. *In re Royka*, 490 F.2d 981, 180 U.S.P.Q. 580 (CCPA 1974). If an independent claim is nonobvious under 35 U.S.C. § 103, then any claim depending therefrom is nonobvious. *In re Fine*, 837 F.2d 1071, 5 U.S.P.Q.2d 1596 (Fed. Cir. 1988); M.P.E.P. § 2143.03.

With respect to alleged obviousness, there must be something in the prior art as a whole to suggest the desirability, and thus the obviousness, of making the combination. *Panduit Corp. v. Dennison Mfg. Co.*, 810 F.2d 1561 (Fed. Cir. 1986). In fact, the absence of a suggestion to combine is dispositive in an obviousness determination. *Gambro Lundia AB v. Baxter Health-care Corp.*, 110 F.3d 1573 (Fed. Cir. 1997). The mere fact that the prior art can be combined or modified does not make the resultant combination obvious unless the prior art also suggests the desirability of the combination. *In re Mills*, 916 F.2d 680, 16 U.S.P.Q.2d 1430 (Fed. Cir. 1990); M.P.E.P. § 2143.01. The consistent criterion for determining obviousness is whether the prior art would have suggested to one of ordinary skill in the art that the process should be carried out and would have a reasonable likelihood of success, viewed in the light of the prior art. Both the suggestion and the expectation of success must be founded in the prior art, not in the Applicant's disclosure. *In re Vaeck*, 947 F.2d 488, 20 U.S.P.Q.2d 1438 (Fed. Cir. 1991; *In re O'Farrell*, 853 F.2d 894 (Fed. Cir. 1988); M.P.E.P. § 2142.

A recent Federal Circuit case makes it clear that, in an obviousness situation, the prior art must disclose each and every element of the claimed invention, and that any motivation to combine or modify the prior art must be based upon a suggestion in the prior art. *In re Lee*, 61

U.S.P.Q.2d 143 (Fed. Cir. 2002). Conclusory statements regarding common knowledge and common sense are insufficient to support a finding of obviousness. *Id.* at 1434-35. "Our case law makes clear that the best defense against the subtle but powerful attraction of hindsight-based obviousness analysis is rigorous application of the requirement for a showing of the teaching or motivation to combine prior art references." *Telefex v. KSR Intern. Co.*, 119 Fed. Appx. 282 (Fed. Cir. 2005) (unpublished) (citations omitted). In making an obviousness rejection, it is necessary for the Examiner to identify the reason why a person of ordinary skill in the art would have combined the prior art references in the manner set forth in the claims.

It is respectfully submitted that any attempt to assert that the subject matter defined by independent claims 1 and 11 is obvious in view of the prior art of record constitutes an impermissible use of hindsight using Applicants' disclosure as a roadmap.

The Office Action asserts that the motivation for combining McGahay and Vines is based on the statement in the abstract that an anneal process is performed on the dielectric layer in order to minimize or eliminate volatile impurities in the dielectric layer. However, the Office Action omits the teaching of Vines that specifically recites those impurities as being water, hydrogen, and hydrocarbon impurities. Clearly, Vines does not contemplate problems arising from nitrogen or nitrogen compounds diffusing through a low-k dielectric. The absence of "nitrogen" in the clam recitation of impurities does not negate the fact that the prior art does not recognize the presence of impurities diffusing through the low-k dielectric layer and their resultant effect of resist poisoning. Because neither McGahay nor Vines does recognizes these types of impurities or their effects, the motivation for combining the reference is lacking. The types of impurities described in Vines are simply not an issue with the process employed by Applicants and set forth in the claimed subject matter. The difference in the types of compounds reduced by offgassing highlights the completely different process situation and completely different process chemistry used in Vines.

It is the claimed invention, as a whole, that must be considered for purposes of determining obviousness. A mere selection of various bits and pieces of the claimed invention from various sources of prior art does not render a claimed invention obvious, unless there is a suggestion or motivation in the prior art for the claimed invention, when considered as a whole. In this case, it is respectfully submitted that the obviousness rejection is improper.

Moreover, the Office Action equates the silicon dioxide layer of Vines to a low-k dielectric layer. This clearly cannot be supported. As indicated on page 3 of Applicants' specification, the transition from the well-known and well-established aluminum/silicon dioxide metallization layer (taught by Vines) to a low-k dielectric/copper metallization layer (taught by Applicants) is associated with a plurality of issues, including resist poisoning due to nitrogen or nitrogen compounds. Vines clearly does not contemplate nitrogen compounds as being a potential issue. Silicon dioxide is not a low-k dielectric material, as asserted by the Office Action in paragraph 4.B. Applicants distinguish silicon dioxide from low-k dielectrics on page 3, lines 9-13. Also, it is notoriously well known in the art that silicon dioxide is considered a high-k dielectric, as compared to the groups of compounds referred to as low-k dielectrics. The mere fact that silicon dioxide contains silicon does not make it a low-k dielectric material as asserted by the Office Action. This mischaracterization of silicon dioxide further highlights the completely different process situation and chemistry employed by Vines as compared to Applicants.

There are no process or chemistry similarities between McGahay and Vines that would lead one of ordinary skill in the art to combine them in the manner suggested by the Office Action. The Office Action fails to consider the claimed subject matter taken as a whole in attempting to combine McGahay and Vines. Due to the marked differences in process situations and chemistry, there is simply no recognition that nitrogen poisoning is an issue with low-k dielectric layers, or that such poisoning may be mitigated by heat treating a low-k dielectric layer. Accordingly, there is no motivation to combine McGahay and Vines, the combination fails to teach all the features of the claimed subject matter in that Vines teaches heat treating a silicon dioxide layer as opposed to a low-k dielectric layer, and finally, there is no reasonable expectation of success when McGahay and Vines are combined, because neither suggests heat treating a low-k dielectric layer prior to forming a cap layer.

For these reasons, the combination of McGahay and Vines fails to teach or suggest the claimed subject matter. Accordingly, claims 1, 11, and all claims depending therefrom are allowable. Applicants respectfully request the rejection of these claims be reversed.

B. McGahay, Vines and Jiang do not obviate claims 7-10 and 17-22.

Claims 7-10 and 17-22 stand rejected under 35 U.S.C. § 103 as allegedly being obvious over McGahay in view of Vines and U.S. Patent Publication No. 2002/0090822 (Jiang).

Jiang fails to correct the defects identified above with respect to McGahay and Vines, and therefore claims 7-10 and 17-22 are allowable for at least the reasons provided above for independent claims 1 and 11. Specifically, Jiang also teaches a cap layer formation step without a preceding heat treatment out-gassing step. Accordingly, the combination of McGahay, Vines, and Jiang also fails to teach or suggest the features of the claimed subject matter. Thus, the art of record fails to obviate claims 1-53 under 35 U.S.C. § 103(a). Applicants therefore respectfully request that the rejections be reversed.

VIII. CLAIMS APPENDIX

The claims that are the subject of the present appeal – claims 1-5, 7-15, and 17-24 – are set forth in the attached "Claims Appendix."

IX. EVIDENCE APPENDIX

There is no separate Evidence Appendix required for this appeal.

X. RELATED PROCEEDINGS APPENDIX

There is no Related Proceedings Appendix required for this appeal.

XI. CONCLUSION

The rejections fail because the cited art of record fails to teach all the limitations of the claims. More particularly, the art of record fails to teach forming a low-k dielectric layer over a substrate, heat treating the substrate to promote out-gassing of volatile materials for a predetermined period of time after forming the low-k dielectric layer, and forming a sacrificial cap layer over the low-k dielectric layer after heat treating the substrate, as is recited in the independent claims and, by virtue of their dependence, the dependent claims. Thus, the art of record fails to obviate claims 1-5, 7-15, and 17-24 under 35 U.S.C. § 103 (a). Applicants therefore pray that the rejections be reversed and the claims be allowed to issue.

Respectfully submitted,

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APPENDIX
(Claims at Issue)

1. A method, comprising:

forming a low-k dielectric layer over a substrate;

heat treating said substrate to promote out-gassing of volatile materials for a predetermined period of time after forming the low-k dielectric layer;

converting an upper portion of said low-k dielectric layer into a protective dielectric to form a sacrificial cap layer after heat treating said substrate; and

patterning said sacrificial cap layer and said low-k dielectric layer.

2. The method of claim 1, wherein converting an upper portion of said low-k dielectric layer includes exposing said substrate to an oxidizing plasma ambient.

3. The method of claim 2, wherein said low-k dielectric layer comprises a silicon-based dielectric material.

4. The method of claim 1, wherein said low-k dielectric layer is formed with a thickness that exceeds a desired final design thickness of said low-k dielectric layer.

5. The method of claim 4, wherein converting said upper portion is continued until the thickness of said low-k dielectric layer substantially corresponds to said design thickness.

7. The method of claim 1, further comprising forming a first resist mask over said sacrificial cap layer and etching a via opening through said sacrificial cap layer and said low-k dielectric layer, wherein resist contamination of said first resist mask is maintained below a specified level.

8. The method of claim 7, further comprising forming a second resist mask over said sacrificial cap layer and patterning an upper portion of said low-k dielectric layer to form a trench over said via opening, the trench having a greater lateral dimension than said via opening.

9. The method of claim 7, further comprising determining a contamination level of photoresist prior to forming said first resist mask.

10. The method of claim 9, further comprising heat treating said substrate to further out-gas said volatile material through said sacrificial cap layer when said determined contamination level exceeds a predefined level.

11. A method, comprising:

forming a silicon-based low-k dielectric layer over a substrate; and

heat treating said substrate dielectric layer to promote out-gassing of volatile materials for a predetermined period of time after forming the low-k dielectric layer;

forming a silicon dioxide layer as a sacrificial cap layer on said low-k dielectric layer after heat treating said substrate, wherein volatile materials continue to out-gas from said low-k dielectric layer prior to and during the formation of said silicon dioxide layer.

12. The method of claim 11, wherein forming said silicon dioxide layer includes converting an upper portion of said low-k dielectric layer into low-density silicon dioxide.

13. The method of claim 12, wherein said upper portion is converted into silicon dioxide by exposing said substrate to an oxidizing plasma ambient.

14. The method of claim 11, wherein said low-k dielectric layer is formed with a thickness that exceeds a desired final design thickness of said low-k dielectric layer.

15. The method of claim 14, wherein converting said upper portion is continued until the thickness of said low-k dielectric layer substantially corresponds to said design thickness.

17. The method of claim 11, further comprising forming a first resist mask over said sacrificial cap layer and etching an opening through said sacrificial cap layer and said low-k

dielectric layer, wherein resist contamination of said resist mask is maintained below a specified level.

18. The method of claim 17, further comprising forming a second resist mask over said sacrificial cap layer and patterning an upper portion of said low-k dielectric layer to form a trench over said via opening, said trench having a greater lateral dimension than said via opening.

19. The method of claim 17, further comprising determining a contamination level of photoresist prior to forming said first resist mask.

20. The method of claim 19, further comprising heat treating said substrate to further out-gas said volatile material through said sacrificial cap layer when said determined contamination level exceeds a predefined level.

21. The method of claim 9, wherein determining the contamination level of photoresist further comprises:

forming a sacrificial resist layer on the sacrificial cap layer;

patterning the sacrificial resist layer; and

determining an amount of resist residuals in the patterned sacrificial resist layer.

22. The method of claim 17, wherein determining the contamination level of photoresist further comprises:

forming a sacrificial resist layer on the sacrificial cap layer;

patterning the sacrificial resist layer; and

determining an amount of resist residuals in the patterned sacrificial resist layer.